Canada–B.C.
Conservation and Renewable Energy Demonstrations

B.C. 10

Energy, Mines and Resources Canada
Conservation and Renewable Energy Branch

Energie, Mines et Ressources Canada
Bureau de la conservation et des énergies renouvelable

Province of British Columbia

Ministry of Energy, Mines and Petroleum Resources
CONSERVATION AND TECHNOLOGY DIVISION

Solar Domestic Hot Water Installation at Grandview Housing Co-op in Vancouver, B.C.

B.C. Ministry of Energy, Mines and Petroleum Resources

and

Sol-Way Solar Engineering Ltd.
Vancouver, B.C.

February, 1984

CANADA/B.C. CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION PROGRAM

CANADA/BRITISH COLUMBIA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well-endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the government of British Columbia and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement. The Agreement is dedicated to the development and demonstration of conservation and renewable technologies.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within B.C.
- To create employment in new or existing energy-related industries.

CREDITS

This project was jointly funded by Grandview Housing Co-operative and the Canada and British Columbia governments under the Canada/ B.C. Conservation and Renewable Energy Demonstration Program.

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SUMMARY

The Grandview Housing Co-operative, in conjunction with Sol-Way Solar Engineering Ltd., installed a solar domestic hot water preheat system in their 19-suite apartment building in Vancouver in December 1981. The system was designed to provide 40% of the building's annual domestic hot water energy needs, saving 114.9 GJ of natural gas per year.

The cost of the system was $29,282; the total project cost was $42,037, including monitoring and information transfer. The funding was provided by the Canada/B.C. Conservation and Renewable Energy Demonstration Agreement (CREDA) and Grandview Housing Co-operative.

The system selected was a drain-down type, with central storage. The cost per dwelling unit was less than for individual systems for each apartment because of the central storage. The central design should also be more efficient because of averaged water demands and water usage diversity. The collector area was reduced relative to the demand, which should result in lower operating temperatures and reduced overheating in summer, thus increasing the solar collecting efficiency.

Monitoring of the system's performance started in mid-1982, using a water flow meter and a gas meter. Based on the data obtained to date, little or no solar energy appears to have been delivered to the Co-op's hot water. No reason has yet been determined for the poor performance, as the system appears to be functioning normally. A BTU meter is now being installed because of concern that the current simple monitoring system may be inaccurate.

INTRODUCTION

The Grandview Housing Co-operative decided, early in the planning phase for their new building, to seek an energy conserving design without adding excessively to the capital costs. The building, aided in financing by Canada Mortgage and Housing Corporation under Section 56 (1) of the National Housing Act, was not to exceed a capital cost of $850,000 for the 19 units ($44,740 per unit). The design was to meet CMHC's "modest housing" guidelines. Although CMHC favours energy conserving design, it makes no allowance for it in the capital cost.

The final design incorporated wall insulation of R-20, roof insulation of R-31, double glazed windows, and a south-facing, 45°-sloping roof that could accommodate up to 90 m^2 of solar collectors, i.e., 4-1/2 m^2 per living unit. The increased costs were within budget.

Subsequently, the Co-op and CREDA jointly funded the installation of a solar domestic hot water system. The residents of the Co-op have taken a strong interest in energy conservation, and have pooled their skills and resources to facilitate the implementation of the project. They are active in the monitoring phase to ensure that the solar system performs up to its specifications.

The project represents typical size and construction of low-rise multi-family dwellings in British Columbia. Rows of older houses are being replaced with this type of living accommodation. The construction is generally three storeys high with flat or pitched roof and underground parking. This arrangement makes the buildings adaptable to the addition of solar-assisted domestic hot water systems. Solar collectors can be located on the ample roof area, water storage can be installed in one of the underground parking bays, and connecting piping can easily pass through the wood frame structure.

It is expected that the project will demonstrate that solar-assisted domestic hot water heating is more cost effective in multi-unit dwellings than in single dwellings, as costs of controls, piping, pumps and storage are reduced when proportioned to each living unit. Also, a "central" system for multiple unit dwellings can take advantage of usage diversity and averaged demand.

The system has been monitored since mid-1982.

SYSTEM DESIGN

Basic Selection Criteria

Two basic system types were considered, drainback and direct dumping, and the latter was chosen. The drainback system would have been the simpler of the two in terms of controls required but would have been less efficient in operation and would require a high pumping head to lift the tank water up four storeys to the solar collectors. The main advantages of the direct dumping system are that the collectors are filled by city pressure and solar-heated water can pass directly to the gas heated tanks for maximum efficiency. However, protection from freezing depends on proper operation of electro-mechanical controls.

Advantages of the selected design over antifreeze systems are that no periodic checks are required on system pressure and antifreeze solution strength, and savings are obtained by using a non-pressurized storage tank.

It was decided that a "central" system would be used, supplying the 19 apartment units from a single storage tank rather than from 19 individual ones. This design takes advantage of usage diversity and averaged hot water demand. Also, operating efficiency is increased through the use of only one heat exchanger.

The system was designed with a relatively low collector area/system demand ratio, which should result in reduced average temperature of the water flowing to the collectors and therefore higher collector efficiency.

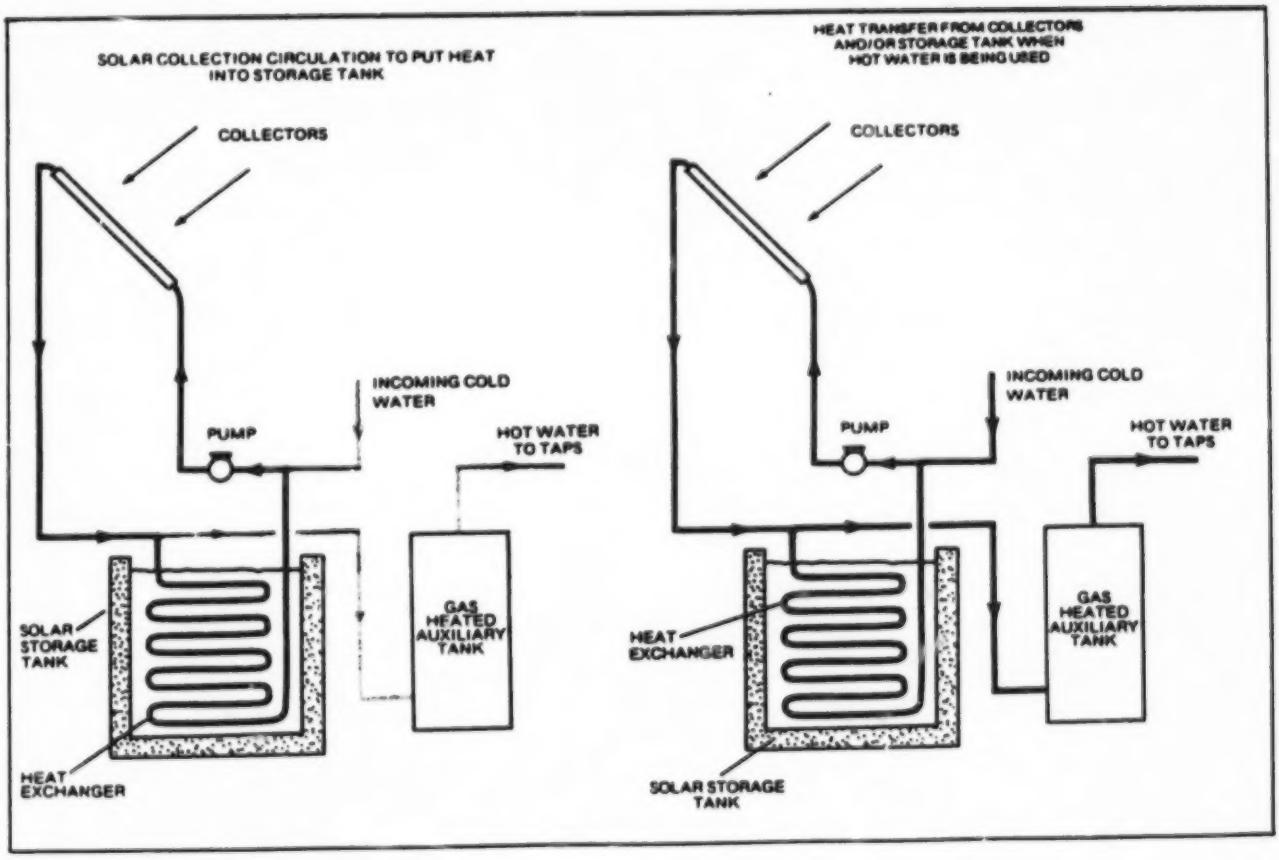
Specifications

The system includes 10 collectors of 2.81 m^2 net area each, for a total of 28.1 m^2. The volume of water storage is 3600 litres. Figure 1 shows the collectors and Figure 2 is a schematic of the system operation.

The collectors are flat-plate, with single acrylic glazing. The absorber plate consists of black-painted aluminum fins molded to copper tubes. The orientation is due south at 45^{o}.

More details are shown in the Appendices.

FIGURE 2


SOLAR COLLECTION CIRCULATION TO PUT HEAT INTO STORAGE TANK
COLLECTORS
INCOMING COLD WATER
PUMP
HOT WATER TO TAPS
SOLAR STORAGE TANK
GAS HEATED AUXILIARY TANK
HEAT EXCHANGER
HEAT TRANSFER FROM COLLECTORS AND/OR STORAGE TANK WHEN HOT WATER IS BEING USED
COLLECTORS
INCOMING COLD WATER
PUMP
HOT WATER TO TAPS
GAS HEATED AUXILIARY TANK
HEAT EXCHANGER
SOLAR STORAGE TANK

Operation

The solar pump turns on when there is sufficient solar radiation, regardless of outside air temperature. The temperature sensor located at the outlet of the most easterly collector senses an increase in temperature when the sun is out. This temperature is compared with an identical sensor in the bottom of the solar storage tank. The two sensors switch the pump on and open the flow valve when the collector temperature is higher than 9°F above the tank temperature, and switch the pump off and close the valve when the temperature difference is 3°F or less. This ensures that only useful heat is put into the tank and that stored heat is not lost back through the collectors.

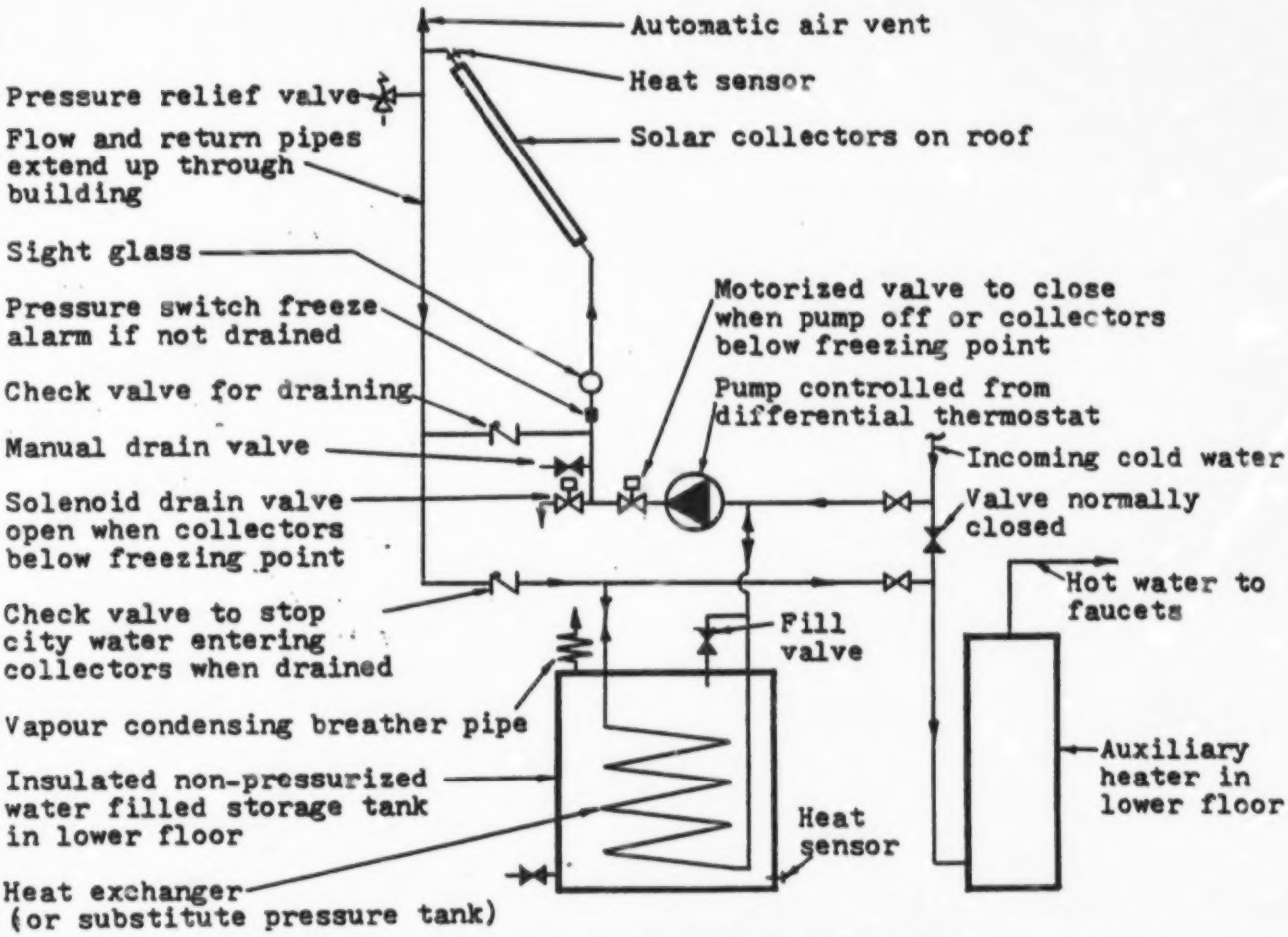
When hot water is being used in the building but at a rate of less than 5 gal./minute, the incoming cold water will flow through the collectors if they are warm. If the rate is greater than 5 gal./minute, incoming cold water will also flow through the solar storage tank. When hot water is not being used, the solar loop will supply heat to the solar storage tank if solar energy is available.

The operation of the system is automatic and does not require periodic or seasonal attention.

FIGURE 3

SOL-WAY® SOLAR ENGINEERING LTD.

P.O. Box 35643, Vancouver, British Columbia, Canada V6M 4G9 Telephone (604) 263 9446


Automatic air vent
Heat sensor
Pressure relief valve
Solar collectors on roof
Flow and return pipes extend up through building
Sight glass
Motorized valve to close when pump off or collectors below freezing point
Pressure switch freeze alarm if not drained
Pump controlled from differential thermostat
Check valve for draining
Incoming cold water
Manual drain valve
Valve normally closed
Solenoid drain valve open when collectors below freezing point
Hot water to faucets
Check valve to stop city water entering collectors when drained
Fill valve
Vapour condensing breather pipe
Auxiliary heater in lower floor
Insulated non-pressurized water filled storage tank in lower floor
Heat sensor
Heat exchanger (or substitute pressure tank)

SOLAR PIPING HOOK-UP FOR DOMESTIC HOT WATER PREHEAT SYSTEMS IN MULTI-STOREY BUILDINGS

Advantages

1. System is filled using city pressure, pump is sized for pipe friction loss only and not for initial fill, resulting in pump energy savings. System drained only when collectors are below freezing.
2. Solar preheated water can enter domestic system directly from collectors during draw off for increased efficiency.
3. No antifreeze system to maintain and no double heat exchanger losses.
4. Only one heat exchanger used for supplying heat to storage and withdrawing heat from storage.
5. Considerable cost savings using non-pressurized corrosion proof plastic tank.

Copyright July 1979.

Figure 1

Controls

Potential failure modes were predicted and back up protection provided, adding to the system's complexity. Similar controls are commercially available for residential-size solar systems but not for larger systems, so they had to be designed and selected from scratch.

The solar collectors and outside piping are protected from freezing by draining when the outside air temperature falls below 45°F. A rise in collector temperature when the sun comes out will cause the system to refill under city pressure and the pump to run as long as there is sufficient heat from the sun. Two freeze thermostats located in the roof space with sensors strapped to the inlet pipe at the most easterly collector, open to break the power to the control circuit upon fall in water temperature. With no power, the pump will stop (if running), the flow valve will close and the dump valve will open causing the system to drain. Two freeze thermostats are provided so that the system will still drain should one fails to operate.

Should the system fail to drain, a self-contained automatic bleed valve located in the roof space will open below 40°F and allow city water to pass continuously through the collectors and run to drain to reduce the chance of freezing. If this happens the control system and valves must be checked for failure.

An alarm buzzer located adjacent to the riser pipes at the ground level will sound if the system has not drained after 3 minutes from a drain down command from the freeze thermostats. A pipe pressure switch in the solar storage room initiates the alarm if the pressure does not fall after 3 minutes.

All control wiring is 24 volt A.C. or less. 120 volt A.C. power is supplied to the control transformer and differential thermostat.

Estimating System Performance

The f-CHART 3.0 computer simulation program was run for the installation, using the values of $F'_R(\tau\alpha) = 0.704$ and $F'_R U_L = 21.64$ KJ/hr. ^oC m^2 based on previous tests.
The program estimated the solar contribution to be 24.2% annually.

f-CHART 3.0 is known to underestimate solar system performance in areas with low average radiation such as Vancouver.

The program was rerun, using updated solar radiation data supplied by John Hay of University of British Columbia in place of the f-CHART data, and using daylight average temperatures instead of 24 hour averages. The solar contribution was estimated to be 30.7%. Most of the increase was due to the corrected radiation figures.

Hand calculation (see Figure 4) estimated the solar contribution to be 57.3% annually. The main difference between this method and f-CHART 3.0 is that the hand calculation assumed a single evening draw-off each day whereas f-CHART assumed a standard distribution.

Using the WATSUN II computer program with 60^o slope, 0^o aspect and 1963 weather data (a fairly normal year), the estimated performance was 35% annually.

f-CHART has a cut-off temperature of 5^oC rise through the collector above storage temperature to allow for double heat exchanger temperature losses. This may result in an underestimate of performance for the Grandview system.

Based on the foregoing, the solar contribution was estimated to be about 40% annually.

FIGURE 4-A

ESTIMATE OF DOMESTIC HOT WATER REQUIREMENTS AND SOLAR CONTRIBUTION

No. of units	- Bachelor	2 x 1 occupant	= 2
	- Single bedroom	5 x 1 occupant	= 5
	- Two bedrooms	5 x 2 occupants	= 10
	- Three bedrooms	7 x 3 occupants	= 21
		Total occupants	38

(Occupancy levels taken from Kitsilano Housing Society data)

Daily hot water consumption = 38 people x 65L/day
= 2470L

Annual hot water consumption = 890,000L

Assume supply temperature = $60^{\circ}C$

Av. incoming cold water = $10^{\circ}C$

Therefore, temperature rise = $50^{\circ}C$

Annual heat requirement = 8.9×10^{5}kg x 4.2 x $50^{\circ}C$
= 186,700 MJ

Annual solar contribution (see next page) = 107,000 MJ

Annual solar percentage = $\frac{107,000 \times 100}{186,700 \text{ MJ}}$
= 57.3%

Backup system efficiency = 65%

Backup gas demand = $\frac{186,700 - 107,000}{.65}$
= 122,615 MJ

FIGURE 4-B

ANNUAL SOLAR CONTRIBUTION

Collector area	:	$30m^2$ single glazed (efficiencies taken from Sol-Way Solar Engineering test data - May 1979)
Collector slope angle	:	45^o due south
Vancouver solar data	:	Fisheries and Environment Canada (J.E. Hay) (calculations assume even distribution over month)
Storage volume	:	$3.6m^3$ plain water
Average morning start up temperature	:	15^oC

Month	Daytime Average Temp. ^oC	Total Incident Sunshine MJ	Tank temp. after Av. daily input (at 70% effy.)	Av. coll. temp. diff. collector-Amb. air ^oC	Corrected average operating efficiency	Actual heat collected MJ
J	4	4 687	22.0	14.5	.7	3 281
F	6	7 560	27.5	15.3	.7	5 292
M	7	12 304	33.5	17.3	.68	8 367
A	11	15 531	39.0	16.0	.69	10 716
M	14	18 767	43.0	15.0	.7	13 137
J	17	17 928	43.0	12.0	.72	12 908
J	20	20 237	45.0	10.0	.73	14 773
A	19	18 414	42.5	10.0	.73	13 442
S	16	15 408	38.0	10.5	.73	11 248
O	12	10 072	30.0	10.5	.73	7 353
N	7	5 319	23.0	12.0	.72	3 830
D	5	3 794	20.5	13.0	.71	2 694
				Annual total	=	107 041 MJ

The total annual domestic hot water energy demand for the building was estimated as follows:

Assume
- number of occupants = 38
- hot water usage per person = 65 litres/day
- hot water supply temperature = 60°C
- average cold water temperature = 10°C
- backup system (gas) efficiency = 65%

Total energy demand = no. of occupants x hot water usage per occupant x temperature differential x specific heat of water
= 38 occupants x 65 L/occupant day x 365 day/yr. x (60 - 10)°C x .0042 MJ/L°C
= 186,700 MJ/yr.

At 40% solar contribution, solar energy supply = 74,700 MJ/yr

Total solar saving = $\frac{74,700}{.65}$ MJ/yr. = 114,900 MJ/yr.

Backup gas demand = $\frac{(186,700 - 74,700)}{.65}$ MJ/yr. = 172,000 MJ/yr.

INSTALLATION

The installation proceeded smoothly with few problems. The major difficulty was drilling the holes through the main floor into the garage. The location was at an undrained low spot in the slab which caused a water problem in the suspended ceiling below.

One plumbing vent had to be relocated to make room on the roof for the collector panels.

An insulated room was constructed around the storage tank by the Co-op members.

PERFORMANCE

Monitoring System

A gas meter to measure auxiliary gas usage, a flow meter to measure the hot water usage, and a timer to measure the amount of time the solar pump has operated were read each month. The incoming cold water temperature was taken to be the water temperature at Vancouver's reservoir. The hot water outlet temperature was measured and found to be 55.5°C and was assumed to remain constant.

The monthly energy requirement was calculated as follows:

$$Q = W \times (55.5 - Tc) \times 4190$$

where Q = energy supplied to water, kJ
W = water usage, m^3
55.5 = hot water temperature, °C
Tc = cold water temperature, °C
4190 = specific heat, kJ/m^3 °C

The energy supplied to the water from the gas is:

$$Qg = G \times 1055 \times 0.7$$

where Qg = energy to water from gas, kJ
G = gas usage, ft^3
0.7 = assumed efficiency of gas system
1055 = energy content of gas, kJ/ft^3

The solar energy supplied, Qs = Q - Qg, in KJ

$$\text{Percent solar contribution} = \left(1 - \frac{Qg}{Q}\right) \times 100$$

In addition, there are several thermometers in the system.

A BTU meter system, including Siemens Calorimetric Counter model M72131 - A121-A2, Neptune Flowmeter type S with type 34 impulse switch and couplings, and matched RTDs model 7MC 1028-8AB, is presently being installed.

Operating Problems

A back-up self-acting freeze protection valve is located on the return line from the collectors to allow city water to move through the collectors should dumping not occur. This valve has a fixed temperature set point that causes the valve to slowly open as the temperature gets colder. This set point is slightly above the coldest cold water inlet temperature thus the valve tends to bleed small quantities of water in cold, cloudy, but above freezing weather. This is a small problem that could be tolerated, or the valve could be removed as it is not absolutely necessary. All the other control functions operate as designed.

Another problem was that the system would dump the water in the collectors at sporadic times during the day. This was caused by the freeze sensing thermostats in the cold water piping switching the dump valves when the incoming cold city water entered the pipe. The set points were turned down to just below the incoming winter cold water temperature to prevent the dumping action.

A piping failure in one collector caused the unit to fill with water and the acrylic glazing to balloon out. The glazing remained in place, however. On removal it was found that a 1/2 inch end cap in the collector had blown out due to city pressure. The metal appeared very thin at the blown out end. This was replaced and the collector reinstalled.

Performance Results

The results to date show virtually no delivery of energy by the solar system to the building's hot water system. However, there is concern that the simple metering system may not be adequate for this application. The solar installation is designed to operate on a relatively low temperature differential between the solar-preheated water and the incoming cold water. An inaccuracy of a few degrees in the incoming cold water temperature or the hot water temperature or in the estimate of gas burner efficiency has a drastic effect on the calculated solar contribution. The inaccuracy of the monitoring system was further illustrated by negative solar loads calculated during some months. The Siemens BTU meter installation will allow us to determine whether the solar system is not working properly or whether the metering has simply not been accurate.

ECONOMICS

The funding for the project was as follows:

	Grandview Housing Co-Op	Canada/BC CREDA	Total
	$	$	$
Installation & Engineering	7,055	22,227	29,282
Monitoring & Information Transfer	-	12,755	12,755
TOTAL	7,055	34,982	42,037

The detailed budget was:

Engineering

Design, drawings and specifications	$2,832
Project control - field supervision, inspection, commissioning, cost control, progress reports.	1,095
TOTAL	$3,927

Installation

	Material	Labour
Roof preparation, etc.	$ -	$ 7,055
Inside piping, storage tanks, controls, etc.	4,550	1,850
Outside piping and solar collectors	6,650	2,550
Insulation		1,600
Cutting, patching and builders' work		750
Electrical		350
	$11,200	$14,155
TOTAL		25,355
GRAND TOTAL		$29,282

The estimated capital cost of the installation = $29,282. First year savings were estimated to be 114,900 MJ of natural gas @ $0.004/MJ = $460.

If the life of the solar installation is assumed to be 20 years, the capital cost would not be recovered through fuel savings for any reasonable estimate of future fuel price escalation rate and discount or interest rate.

If the installation was displacing oil instead of gas, the estimated first year savings would be

$$114.9 \text{ GJ} \times \frac{1 \text{ gal}}{0.177 \text{ GJ}} \times \$1.22/\text{gal} = \$792.$$

This assumes 65% oil burning efficiency. At annual discount rate of 9% and annual fuel inflation rate of 15%, and ignoring maintenance expenditures, the installation would pay for itself in 20 years on cumulative fuel savings. That is, the present worth of the cumulative fuel savings would be approximately $29,282. With lower discount rates, the system would pay for itself at lower fuel inflation rates.

If the installation was displacing electricity instead of gas, and assuming efficiency of 100%, the estimated first year savings would be $74{,}700 \text{ MJ} \times \frac{1 \text{ kWh}}{3.6 \text{MJ}} \times \$0.034/\text{kWh} = \$706$. At 8% discount rate and no maintenance, the installation would pay for itself in 20 years at fuel inflation rate of 15%.

POTENTIAL IMPACT

There is marginal potential for replication for multi-family dwellings that use oil or electricity for their auxiliary fuel. For gas auxiliary, the solar heating system is not economical.

Government subsidy would make the economics more attractive to buyers. Since oil and electricity are both subsidized, a solar subsidy might also be justified.

CONCLUSIONS AND RECOMMENDATIONS

The solar design is not economically viable unless subsidized, but its innovativeness makes it a good development project. The performance of this installation will be indicated when the BTU meter monitoring is underway.

APPENDICES

Sol-Way Solar Engineering Ltd.
942 S.W. Marine Drive
Suite 30
Vancouver, British Columbia
V6P 5Z2
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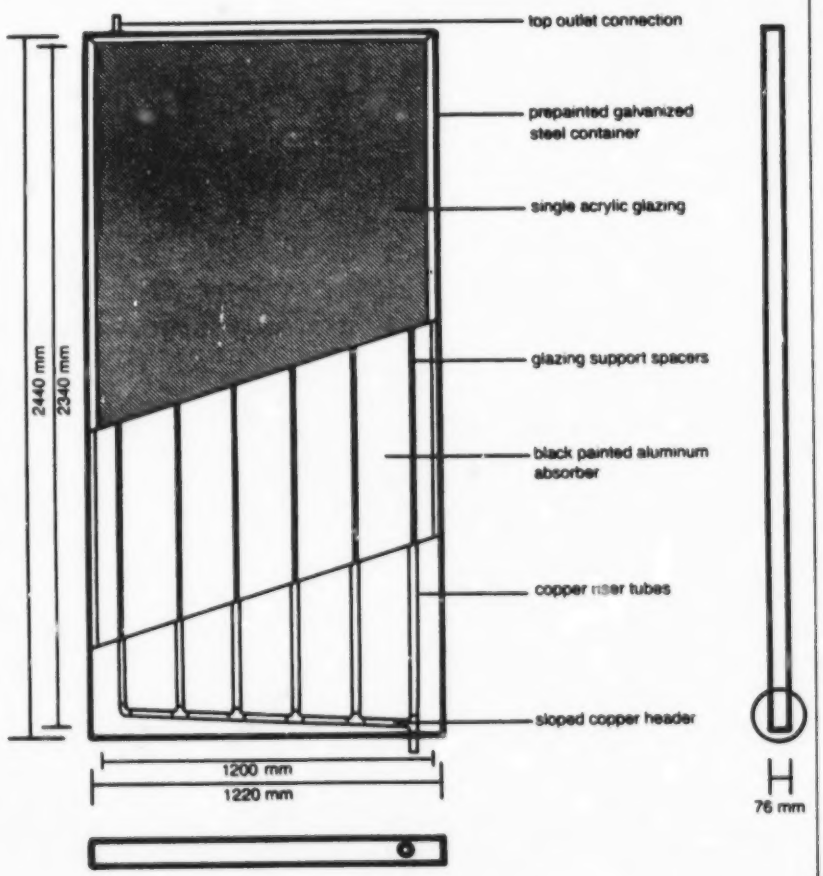
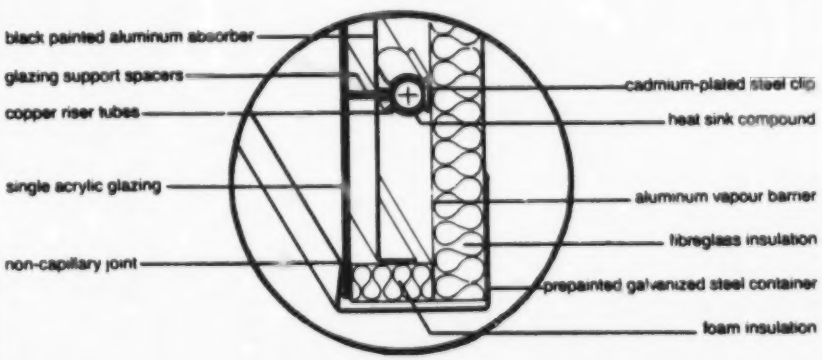
(604) 324-3327

Sol-Way SAP
Liquid Flat Plate Collector





A. General Information

1. Product Description:
The Sol-Way SAP liquid flat plate collector is single glazed with flat acrylic, and the absorber consists of black painted aluminum fins moulded to copper tubes. Internal copper headers are sloped for positive drainage. Container consists of a prepainted galvanized steel frame to hold the glazing and fiberglass insulation, and to provide the weather-seal. Collectors are designed for drain back operation.

1.1 Options:
Lexan glazing, flashing to cover hook-up manifold and roof brackets, copper absorber plate with black chrome finish, smaller 1220 mm × 1830 mm collector, custom sizes on request.

1.2 Dimensions:
1220 mm × 2440 mm × 76 mm
Gross area: 3.01 m²
Net absorber area: 2.81 m²

1.3 Weight:
Net weight: 47 kg (104 lb.)
Shipping weight: 60 kg (132 lb.)

2. Product Use:

2.1 Product Applications:
Process and domestic hot water, swimming pool heating, short-term space heating.

2.2 Geographic and Climatic Limitations:
All cold climate regions.

3. Manufacturer's Experience:

3.1 Background:
Sol-Way Solar Engineering Ltd. was incorporated in 1979 and specializes in the manufacture, design, and marketing of solar water heating equipment and systems.

3.2 Production:
300 m² per month production capacity.

3.3 Projects:
Mostly apartment and residential DHW and swimming pool heating systems in southern British Columbia.

C. Absorber System

1. General Description:
The absorber consists of aluminum sheet fins moulded around six parallel copper riser tubes which are soldered to concealed sloped copper headers at the top and bottom. Cadmium-plated spring steel clips hold the absorber and riser tubes together and also support the plastic glazing spacers. Absorber coating is a flat black heat resistant paint on an etch-bond primer. A copper absorber plate with black chrome selective surface is optional. All soldered joints employ standard plumbing fittings.

1.1 Generic/Trade Names:
Sheet aluminum, copper tubing, Tremclad heat resistant paint.

1.2 Chemical Composition:
Absorber: utility grade aluminum
Risers: Type L copper
Headers: Type L copper

1.3 Physical Treatment:
Flat black heat-resistant paint is applied over an etch primer. Optional black chrome is electroplated over a nickel underlay.

1.4 Dimensions:
Riser diameter: 16 mm (⅝ in.)
Riser spacing: 203 mm (8 in.)
Aluminum absorber: 0.64 mm (0.025 in.)
Header diameter: 16 mm (⅝ in.)
Copper absorber: 0.3 mm (0.010 in.)
Paint: 0.08 mm

2. Optical Performance:

2.1 Absorptivity of Solar Radiation:
Black paint: 90% (estimated by Sol-Way)
Optional black chrome: 93% (data from Berry Solar Products)

2.2 Emissivity of Infrared Radiation:
Black paint: 90% (estimated by Sol-Way)
Optional black chrome: 6% (data from Berry Solar Products).

3. Thermal Performance:

3.1 Thermal Transfer:
Heat is transferred from the absorber surface to the solar fluid in parallel flow upward through the risers from the sloped internal header.

3.2 Coefficient of Thermal Expansion:
Copper: 16.7×10^{-6} m/m.°C
Aluminum: 24.3×10^{-6} m/m.°C
The mechanical joint is augmented with a non-drying heat-transfer compound.

3.3 Thermal Capacity:
Copper/aluminum absorber has specific heat of 2.94 kJ/°C.m²; the all copper absorber is 1.92 kJ/°C.m².

3.4 Maximum Use Temperature:
120°C

3.5 Minimum Use Temperature:
- 10°C

4. Mechanical Integrity:
Panels have been tested through cycles of freezing and stagnation without mechanical failure. Components are free to expand and contract with temperature extremes.

Direct Mounted Two Collector Array, Nanaimo, B.C.

E. Collector Assembly

1. General Description:
Collector is assembled face down. The absorber plate and glazing supports are laid onto the glazing. The rigid insulation is set in place and the sprung frame is applied, with corner brackets held in place with sheet metal screws.

1.1 Glazing:
The glazing is held in place by the outer frame, but is free to move without interfering with the friction fit water seal.

1.2 Absorber Assembly:
Absorber plate is held to the container at the header connections and with the bottom brace. Rubber grommets isolate the frame from the outlets, leaving the absorber assembly free to move within the container.

1.3 Insulation:
The rigid fibreglass board insulation is contained by the rear flange of the outer frame. The foam insulation is wedged between the absorber and the sides.

1.4 Collector Container:
The frame supports the rear insulation and clamps down on the glazing to provide the weather seal.

2. Collector Container:

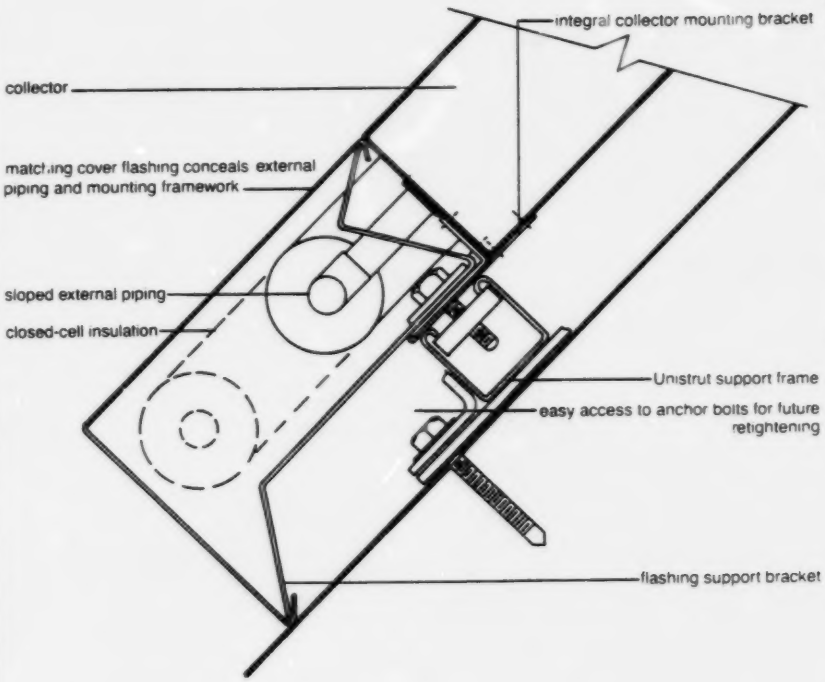
2.1 Materials:
0.025 mm (24 gauge) prefinished galvanized steel.

2.2 Finish:
Dark brown enamel, *ASTM D1005, CGSB 1GP71*. Other colours are available on request.

3. Moisture Control System:
Five 9 mm weep and breather holes along bottom edge; 3 mm vent tube at top of collector.

4. Sealants and Gaskets:
No sealant or gaskets are used. The sprung outer frame provides non-capillary active sealing.

Flashing for External Manifolds

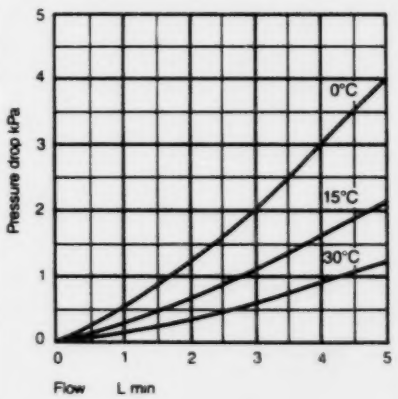

integral collector mounting bracket
collector
matching cover flashing conceals external piping and mounting framework
sloped external piping
closed-cell insulation
Unistrut support frame
easy access to anchor bolts for future retightening
flashing support bracket

Sol-Way SAP
Liquid Flat Plate Collector

G. Operation

1. **General Method of Operation:**
Collectors operate with a parallel vertical flow through the collectors from the bottom to the top opposite end of the array. The internal headers are sloped for positive venting and rapid draining as the collectors are designed primarily for drain back systems although closed loop antifreeze circuits can be used.

2. **Pressure Drop vs. Collector Flow:**



Pressure drop was measured using a 50:50 water:propylene glycol heat transfer fluid.

2.1 **Testing Agency:**
Ontario Research Foundation

3. **Recommended Flow Rate:**
1.5 to 9.0 litres per minute per collector, depending on system design.

4. **Maximum Operating Pressure:**
690 kPa (100 psi)

5. **Maximum Operating Temperature:**
120°C (250°F)

6. **Stagnation Temperature:**
150°C (300°F) for painted absorber surface: no data available on black chrome absorber surface.

7. **Heat Transfer Fluid:**
Any fluid compatible with copper: corrosion inhibitors may be required, depending on local water analysis.

H. Maintenance

1. **Cleaning and Maintenance:**
No routine maintenance is required, although the collector glazing will require hosing down during dry weather to reduce surface dust.

2. **Manufacturer Servicing:**
An owner's manual with a trouble-shooting guide is supplied with each order. A field inspection service is available in the lower mainland, B.C. area.

3. **Availability of Parts:**
Most collector components are standard construction items and can be purchased locally.

4. **Replacement of Parts:**
Leaks in copper tubes and joints can be repaired on site with 95:5 tin:antimony solder.

Collector must be removed from the array if the absorber or glazing requires replacement: capping the stub connections on the manifolds allows the rest of the array to remain in operation.

Glazing is best replaced by disassembling collector on a table. Acrylic is more resistant to impact than tempered glass and fractures can be repaired in place with solvent weld fluid.

I. Durability

1. **Operating Experience:**

1.1 **Location:**
Kitsun Co-op Housing
Vancouver, B.C.

1.2 **Time Span:**
Installed spring 1979.

1.3 **Repairs:**
None.

1.4 **Modifications:**
Absorber paint absorptivity has improved.

1.5 **Independent Assessment:**
Solar Applications and Research Ltd.
3683 W. 4th Avenue
Vancouver, B.C.

(604) 733-5631

2. **Accelerated Aging Tests:**
No detailed tests have been carried out.

Direct Mounted Three Collector Array, Vancouver, B.C.

DIFFERENTIAL TEMPERATURE THERMOSTAT

. . . for solar heating and
solar hot water system control

DELTA-T™

PATENT PENDING

Enclosure is standard 4-11/16" by 4-11/16" UL Listed electrical outlet box (11.9mm x 11.9mm)

DESCRIPTION

The DELTA-T™ Differential Temperature Thermostat is an automatic motor control which turns on and off the circulation pump/blower in a solar heating or solar hot water system when the collector temperature exceeds the storage temperature by preset differentials.

Also, in reverse, the DELTA-T™ may be utilized in solar nocturnal cooling systems to control summer night cold pick-up. By reversing the sensor locations (high temperature sensor at storage and low temperature sensor at cool exterior location), the pump or blower will go on when the exterior is colder than storage.

→ The DTT-90, -91 and -92 are designed to be hooked-up without the need to hire an electrician as they are equipped with a grounded power supply cord and a receptacle outlet in the box cover.

A feature of the DTT-100 series is an AUTOMATIC OFF condition when the collector temperature is below 80°F. This feature prevents the pump turning on at night when a large amount of heat has been extracted from storage.

A circuit to turn the pump on during freezing temperatures is incorporated into the DTT-200 series. This feature prevents damage to the collector from freezing by circulating the warmer storage water. The pump turns on at 36°F and off when the collector is heated up to 37.5°F.

The DTT-400 series is designed with a high limit control of the storage temperature. When the storage tank is 160°F or higher, the pump will not run. By keeping the water temperature below 160°F, the fear of scalding is eliminated and a precautionary mixing/tempering valve is not needed.

All models have a bypass switch which allows the pump to be turned OFF or ON, bypassing the thermostat.

Construction is all solid state electronics except one UL Listed 10 Amp, 1/3 HP, 120V relay which is designed for 10 million mechanical cycles.

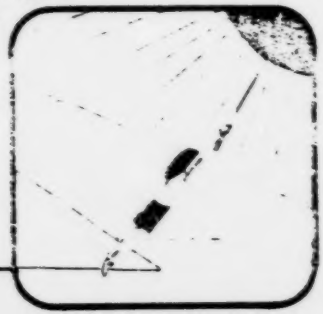
All models are optionally available with a Normally Closed relay function by specifying "NC" after the part number.

For applications requiring higher than 1/3 HP, or 24V AC output, compatible relays and transformers are shown on the reverse side.

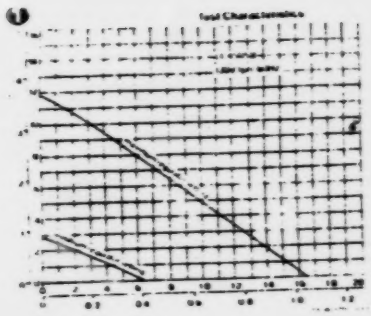
An indicator light on the front plate of the DELTA-T shows when the temperature differentials are in an ON condition.

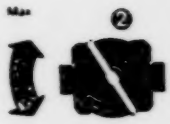
INSTALLATION

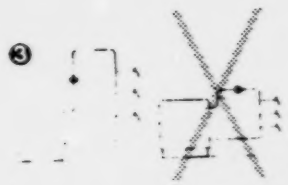
Installation is easily accomplished by running 115V to the box and from the box to the motor. Thermistor Ends for the sensor leads are furnished with the unit. The customer provides the interconnecting 18/2-lead wire which connects the low voltage DC sensor leads to the Thermistor Ends for which connectors are furnished. Hardware to attach Thermistor Ends to pipes, flat surfaces or curved surfaces is also furnished.

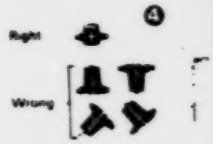


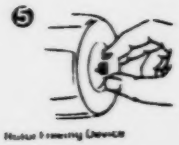
HELIOTROPE GENERAL, 3733 kenora drive, spring valley, ca. 92077
(714) 460-3930

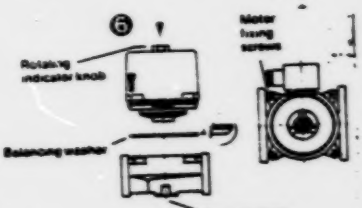












Myson International Limited
Colchester England
Telephone Colchester (0206) 61421
Telex 987185 Cables Mysonex Colchester

MYSON

The Myson 'L' series circulating pump

Installation and operating instructions 60Hz bronze

THE SYSTEM

The system must be thoroughly flushed to remove all loose particles of solder and jointing materials etc.

PERFORMANCE

The curve (diagram 1) shows the range of performance available. The output of the pump may be regulated, within the limits shown, by adjustment of the lever on the back of the pump (diagram 2). The pump should be installed with the lever set to maximum position and adjusted to give satisfactory circulating temperatures when the circuit is stabilised. Too high a performance may result in water noise and high heat losses. When valves are fitted, these should not be used for performance variation.

Myson LC45 pump is suitable for the following:

Max. water temperature	230 F (110 C)
Max. system pressure	147psig (10kg/cm²)
Max. ambient temperature	110°F (50° C)
Voltage Supply	115 Volt, 1 ph, 60Hz
Input Power nominal	80 Watts
Input Current nominal	0.7 Amp
N P S H Required	7 ft w.g. (2m w.g.)

INSTALLATION

The pump should be installed on a vertical pipe and not at a high point where air could collect. *See diagram 3.*

The pump must be installed with the rotating shaft in the horizontal plane. *See diagram 4.*

To conform with C.S.A. drip-proof requirements, the terminal box must be uppermost.

Do not run pump dry.

The pump is self purging of air.

If the motor head position is changed or the unit replaced then the following must be observed. *See diagram 6.*

1. Assemble in direction of arrow.
2. Balancing washer must be assembled as shown.
3. Tighten motor fixing screws in a diagonal pattern, in stages to a final torque of 22 lb in (25 kg cm).
4. Check for free rotor movement by loosening rotation indicator knob and withdrawing screw to engage rotor shaft. Rotor should turn freely with finger tip force.
5. Screw in rotor freeing device.
6. With pump running, check for noise over full flow regulator adjustment.
7. If noisy, slacken and retighten screws as note 3.

ELECTRICAL WIRING

No ancillary starting equipment is needed.

A 3 Amp. fuse is adequate.

Connect the HOT WIRE to BLACK motor lead. Connect GROUND WIRE to WHITE motor lead. The safety mechanical ground may be connected to the green ground screw located inside terminal box.

STARTING

Turn on water supply and open isolating valves and purge air from system.

Before switching on pump, the rotor freeing device should be unscrewed and pulled out until it engages the motor shaft. *See diagram 5.*

Switch on power and check rotation.

Screw in rotor freeing device.

Run pump for at least fifteen minutes, cycling ON and OFF several times.

FAULT FINDING

A. NO HEAT

1. Ensure arrow on the impeller housing is in direction of flow.
2. Check electric supply to pump terminals.
3. Ensure all valves are open, and that motorised valves are operating correctly.
4. Check system is purged of air.
5. Switch off power.

Unscrew rotor freeing device to engage pump shaft. *See diagram 5.* Pump shaft should turn freely. Turn on power and set controls to pump.

Black nut must spin in same direction as arrow. If black nut does not spin or cannot be turned manually, pump should be replaced. After checks the rotor freeing device should be screwed in.

B. NOISY PUMP

1. Ensure pump is supported in pipework and not transmitting vibration.
2. Ensure valves are fully open.
3. Ensure system is purged of air.
4. Unscrew rotor freeing device. Press sideways with finger pressure for five seconds. Air together with water may leak out. Screw in rotor freeing device.
5. With pump running, move flow regulator (if fitted) from maximum to minimum flow five times and check best position for quiet running. *See diagram 2.*

GRANDVIEW CO-OPERATIVE HOUSING

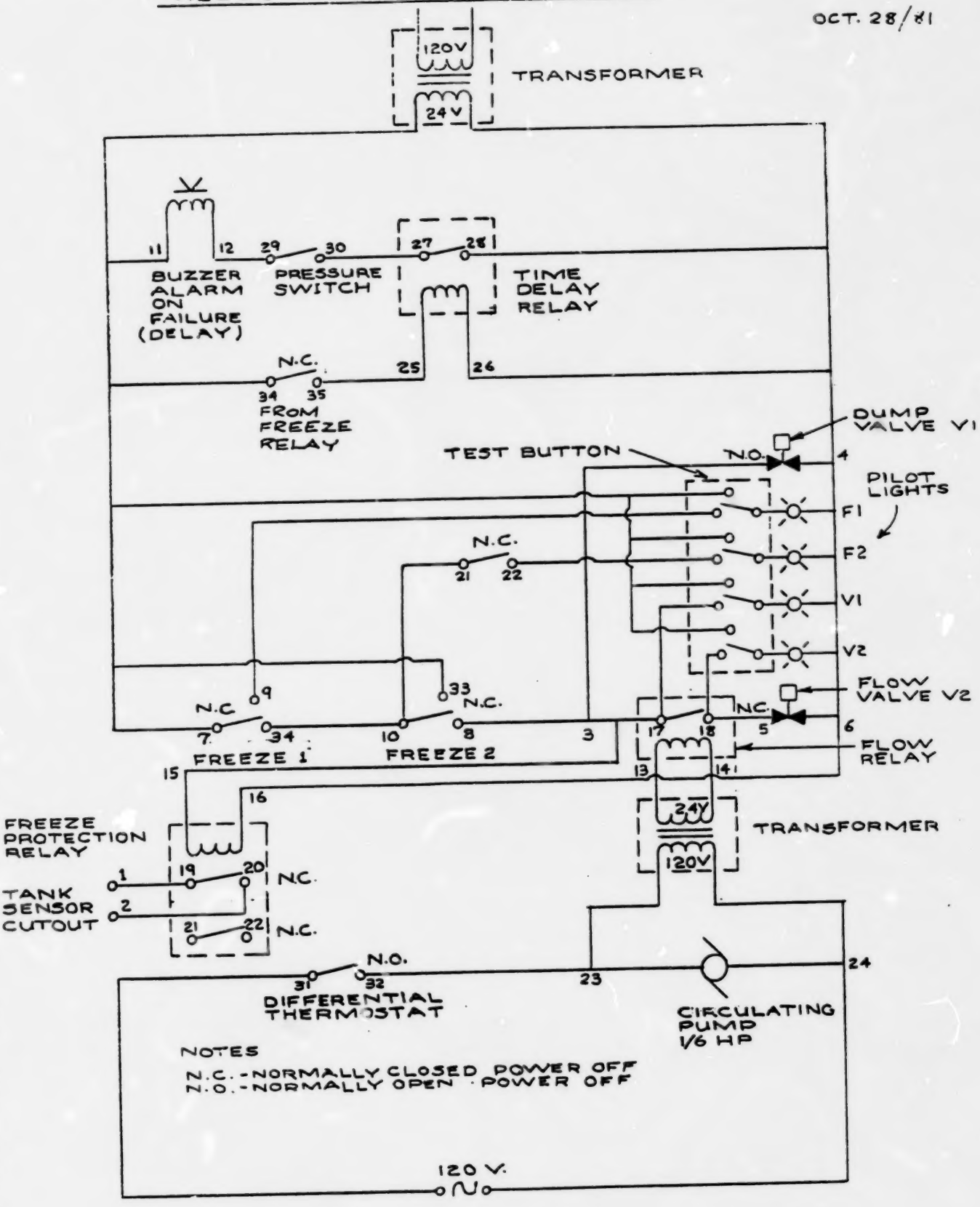
SOLAR PROJECT

VALVE SCHEDULE

IN SOLAR ROOM	No.	SERVICE	LOCATION	NORMAL POSITION
	V1	Dump Valve	Left of control panel	open - power off
	V2	Flow Valve	Below control panel	closed - power off
	V3	Inlet Valve (Shut-off)	Right of control panel	open
	V4	Pressure Relief Valve	Right of inlet valve	closed
	V5	Drain Valve	Below inlet valve	closed
	V6	Shut-off Valve	Below dump valve	open
	V7	Vacuum Breaker	Above dump valve	-
	V8	Check Valve	In front of pressure gauge	-
	V9	Check Valve	In front of pressure gauge	-
	V10	Check Valve	Below pressure gauge	-
	V11	Drain Valve	Below check valves	closed
	V12	Vacuum Breaker	Left of pressure gauge	-
	V13	Automatic Air Vent	Hot line from collectors	-
	V14	Automatic Air Vent	Inlet line above inlet valve	-
	V15	Automatic Air Vent	Hot line to existing tanks	-
	V16	Storage Tank Fill Valve	On top of storage tank	closed
	V17	Storage Tank Drain Valve	At bottom of storage tank	closed
IN MECHANICAL ROOM				
	V18	Flow Meter Shut-off Valve	Above flow meter	open
	V19	Flow Meter Shut-off Valve	Below flow meter	open
	V20	Flow Meter By-pass Valve	Right of flow meter	closed
	V21	Shut-off Valve	Cold inlet	open
	V22	Shut-off Valve	Hot from solar system	open
	V23	System by-pass Valve	Between V21 & V22	closed
IN ROOF SPACE				
	V24	Automatic Air Vent	Hot line from collectors	-
	V25	Automatic Air Vent	Hot line from collectors	-
	V26	Vacuum Breaker	Hot line from collectors	-
	V27	Pressure Relief Valve	Hot line from collectors	closed
	V28	Freeze Protection Valve	Hot line from collectors	closed

GRANDVIEW HOUSING CO-OP
FREEZE PROTECTION CONTROLS

OCT. 28/81



PILOT LIGHTS ON CONTROL RELAY BOX

Pilot lights indicate:-

- V2 (green) - Pump on, flow valve V2 open.
- V1 (green) - Dump valve closed.
- F1 (red) - Freeze thermostat F1 open, system drained.
- F2 (red) - Freeze thermostat F2 open, system drained.

Normal operating modes are as follows:

	Green V2	Green V1	Red F1	Red F2
No control power	o	o	o	o
Mild day, no sunshine or at night	o		o	o
Mild day with sunshine. collecting solar heat			o	o
Cold day no sunshine or at night	o	o		
Cold day with sunshine. collecting solar heat.			o	o
MALFUNCTION WARNING Cold day no sunshine or at night. Only one freeze thermostat open.	o	o		o
	o	o	o	

Check controls.

NOTE: This may occur for a short period as the system cools down due to a small difference between the set point of the two freeze thermostats.

Burned out lights can be checked using the test button.

Pilot lights are for information only. The system is fully automatic.

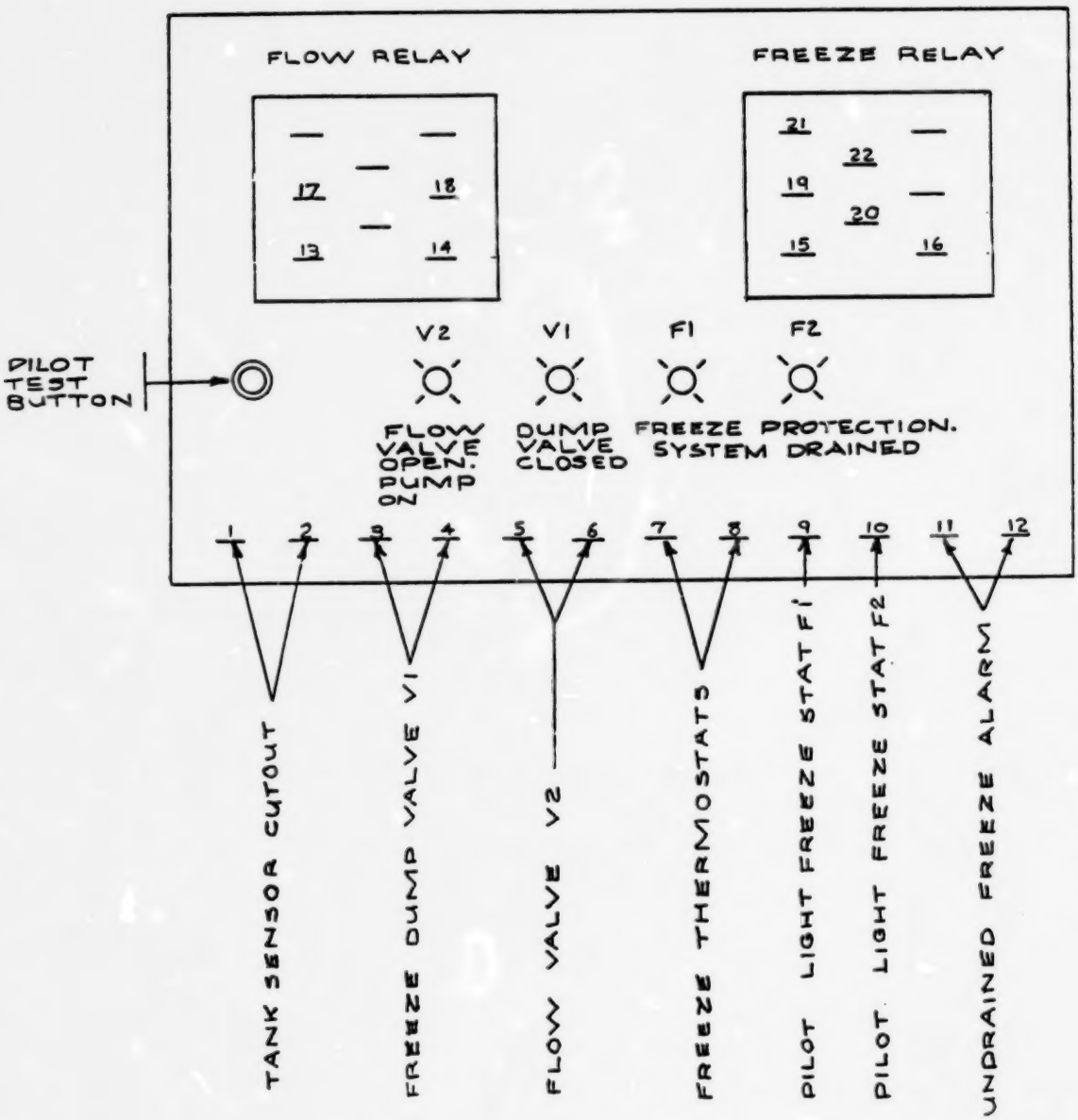
IN THE EVENT OF MALFUNCTION, LOSS OF WATER AT ROOF, OR FAILURE TO DRAIN, (RED PILOT LIGHT(S) ON AND PRESSURE GAUGE READING ABOVE ZERO), ISOLATE AND MANUALLY DRAIN SYSTEM BY THE FOLLOWING PROCEDURE:

(1) PULL WALL PLUG TO SHUT OFF CONTROL SYSTEM.
(2) CLOSE VALVES V21 AND V22, OPEN VALVE V23 IN GAS HEATER ROOM.
(3) OPEN VALVES V5 AND V11 IN SOLAR ROOM.
(4) CALL SOL-WAY SOLAR ENGINEERING LTD., 324-3327 or 263-9446.

CONSULT MAINTENANCE MANUAL FOR FURTHER INFORMATION.

OCT 29/81

GRANDVIEW HOUSING CO-OP
CONTROL RELAY PANEL



1.0 TIPS TO GET THE MOST SAVINGS WITH YOUR SOL-WAY SOLAR HOT WATER SYSTEM

In general,your SOL-WAY SOLAR HOT WATER SYSTEM is designed to provide you with the best combination of efficiency, cost, safety, and long term reliability to give you the best value for your energy dollar.

The solar system operates by preheating the cold water entering the gas or electric water tank, thus the fuel consumed by the tank is only that required to raise the temperature through the remaining degrees to the set point. Your normal supply of hot water will remain unchanged regardless of the weather (you will be glad to know!). You will notice the difference only in the energy consumption.

1.1 CONSERVE WATER

Do not run hot water unnecessarily. Your best energy saving is conserved energy.

1.2 REDUCE TEMPERATURE

Turn set point temperature of auxiliary gas or electric water heater down to the lowest that you can use it at so that little or no cold water is required to be mixed at the taps. (120°F or 50°C should be adequate). If you have a dishwasher check the minimum temperature that it will provide a good wash.

1.3 RE-INSULATE EXISTING TANK

Wrap extra insulation around the auxiliary hot water heater. This, along with a reduced temperature will reduce the wasted 'standby' losses from the tank surface.

1.4 INSULATE PIPING

Insulate the hot water piping from the tank to outlets as much as possible. This will reduce the amount of water that has to be run off before the hot water reaches the outlet.

1.5 STAGGER LARGE DRAW OFFS

Wait for approx. ½ - 1 hour after large water use such as taking a bath or shower, or using a washing machine before running a second large draw off. This will give time for the heat from the outer tank to transfer into the cooled inner tank.

1.6 DO LAUNDRY DURING SUNNY DAYS

Try to do laundry or other activities using large amounts of hot water on sunny days when the solar storage tank is likely to be the warmest.

1.7 BATH OR DO LAUNDRY IN EVENINGS

Use the larger quantities or water in the evening rather than the following morning. This will reduce heat being lost from the tank whilst sitting overnight.

2.0 GENERAL CARE OF SYSTEM

2.1 CHECK SYSTEM IS RUNNING DURING SUNSHINE

Check occasionally that the system is operating during sunny weather (pump running). You will notice that the pump responds more readily to hazy sunshine when the storage tank is cooler. (Do not turn the pump on manually to demonstrate operation during freezing weather).

2.2 CHECK FOR DIRT BUILDUP ON COLLECTORS

Periodic rain is usually sufficient to keep the solar collector glazing clean enought for solar collection but should dirt and dust build up during dry spells the collectors should be hosed down and a soft mop used with plenty of water if within easy reach. The glazing is acrylic (as plexiglas) and can be easily scratched by sharp particles.

2.3 DO NOT RUN PUMP WHEN DRY

This will cause damage to the internal bearings. The pump is a magnetic drive, water lubricated type and requires no maintenance.

2.4 DO NOT TURN OFF DURING HOLIDAYS

When going on holiday the system should be left on automatic operation, and with no water usage will not rise in temperature above about 180^{o}F or 82^{o}C.

The collectors can rise in temperature to 300^{o}F or 150^{o}C under bright sunshine with no water circulation (stagnation). This may reduce the long term operating efficiency if exposed to this temperature for extended periods. When you have a neighbour check the house while away, they should also check the solar system.

2.5 DO NOT TAMPER WITH VALVE POSITIONS UNLESS DISCUSSED WITH DEALER

4.0 NECESSARY MAINTENANCE

4.1 CHECK WATER LEVEL EVERY 6 MONTHS

The normal water level is approximately level with the top of the heat exchanger when water is cold. Top up with plain water from the valve provided near the top. See marking on tank level gauge.

4.2 CHECK OIL FILM ON WATER SURFACE EVERY 6 MONTHS

A gravy appearance indicates that the heavy mineral oil does not completely cover the surface. This will cause heat and water to be lost by evaporation from the exposed water surface. Apply more oil until the surface is completely covered again.

4.3 CHECK FREEZE PROTECTION

Each Fall, pull power plug on wall to check that system drains properly. Replace plug when flow has stopped.